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Cedar Creek Dam,
Columbia Falls,
Montana, Flathead
County, MT-1455

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

CEDAR CREEK DAM
COLUMBIA FALLS, MONTANA
FLATHEAD COUNTY
MT-1455

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PREPARED FOR:

HONORABLE THOMAS L. JUDGE
GOVERNOR, STATE OF MONTANA

CITY OF COLUMBIA FALLS
(OWNER AND OPERATOR)

PREPARED BY:
CH2M HILL
BELLEVUE, WASHINGTON

OCTOBER 1980

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EXECUTIVE SUMMARY

Under contract with the Seattle District Corps of Engineers, and with representation from the Corps, the State of Montana Department of Natural Resources and Conservation (DNRC), the U.S. Soil Conservation Service, and the City of Columbia Falls, CH2M HILL inspected Cedar Creek Dam on October 31, 1979, under the authority of Public Law 92-367. The dam is located on Cedar Creek in Flathead County, about 3 miles northeast of Columbia Falls, Montana.

This report was compiled from information obtained during onsite inspection, from review of construction plans, and from analysis of available hydrologic information. Findings were compared with engineering criteria that are currently accepted by most private and public agencies engaged in dam design, construction, and operation.

FINDINGS AND EVALUATION

Cedar Creek Dam is owned and operated by the City of Columbia Falls. The dam and reservoir are used to store water for municipal use in Columbia Falls, and for flood protection. The 50-foot-high earth dam, designed by the U.S. Soil Conservation Service, impounds approximately 2,720 acre-feet of water at top of dam, elevation 3246.8 feet National Geodetic Vertical Datum (NGVD), based on levels taken at the time of the site visit and using elevation 3226.5 feet NGVD for the crest of the principal spillway. On the basis of criteria in U.S. Army Corps of Engineers "Recommended Guidelines for Safety Inspection of Dams" (Ref. 1), the project is intermediate in size. The dam is located such that its failure could endanger many lives and cause flooding of many homes on the outskirts of Columbia Falls. Additional property damage could result from flooding of an aluminum plant, a lumber mill, the Burlington Northern Railroad tracks, a county road, and portions of the city of Columbia Falls. However, no dam breach analysis or routing of a dam breach flood was made for the downstream area. The conclusions on probable damage are based on a brief field visit and engineering judgment.

The project is classified as having a high (Category 1) downstream hazard potential. Inspection criteria (Ref. 1) recommend that the spillway design flood for an intermediate-sized project with a high downstream hazard potential be the probable maximum flood (PMF). The PMF is the flood expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region.

An estimated thunderstorm PMF was developed for the 12.7-square-mile drainage basin during this dam safety study. The PMF

resulting from the 6-hour thunderstorm has an estimated volume of 4,930 acre-feet and a peak flow of 34,000 c.f.s. The emergency spillway and the principal spillway have combined maximum discharge capacity of 2,300 c.f.s. with the reservoir at top of dam, elevation 3246.8 feet NGVD. The routing of the PMF was started with the reservoir 8 feet below the emergency spillway crest. Routing of the PMF and lesser floods indicates that the project can control a flood having ordinates equal to approximately 45 percent of the PMF ordinates. The dam is constructed of materials that would quickly erode and rapidly fail when overtopped by floodwaters. Such failure would endanger many lives and cause property damage downstream of the dam.

A visual inspection of the dam embankment revealed neither longitudinal nor transverse cracking. Some seepage was observed in the right abutment 200 feet downstream of the embankment toe, and a small wet area was noticed 10 feet downstream of the embankment toe near the left abutment. There is substantial information on foundation conditions and embankment materials, including logs of drill holes and laboratory testing on embankment materials. Stability analyses for static and seismic loadings also are on file. Based on a review of as-built plans, the site visit, and available field and laboratory test data, it is our judgment that the dam embankment conforms with recommended guidelines; however, a check of embankment stability based on water levels obtained from piezometric observations is necessary.

The 30-inch discharge conduit for the principal spillway and outlet works could not be inspected during the site visit because of its small diameter and water conditions. Some small trees were growing in the emergency spillway. There is no formal downstream warning plan for use in the event of impending dam failure. On the basis of the field inspection and study of hydrologic data, Cedar Creek Dam does not now conform to Corps guidelines with respect to discharge and/or storage capacities to safely handle the PMF. Because the project is incapable of controlling the PMF without overtopping and causing the dam to fail, Cedar Creek Dam does not meet inspection guidelines.

RECOMMENDATIONS

Because of storage between normal pool and dam crest, the present project provides a certain degree of flood protection to the downstream area. The intent of report recommendations is to maintain or improve project safety, if feasible, while preserving existing flood protection.

The following actions are recommended:

- Develop and immediately place in action a downstream warning plan, for use in the event of possible dam overtopping or structural failure.

- Inspect the entire length of outlet conduit and repair as required.

- Clear the small trees from the emergency spillway.

- Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and required spillway capacity, and modify the project as the studies indicate.

- Install piezometers along the dam and both abutments. Determine cause of right abutment seepage.

- Check embankment stability using water level data obtained from piezometric observations.

- Conduct periodic inspections of the project at 5-year intervals by engineers experienced in dam design and construction.

Prior to implementing report recommendations, the owner is urged to coordinate work with the State of Montana Department of Natural Resources and Conservation (DNR&C) Dam Safety Office to ensure compliance with all pertinent laws and regulations.

Richard L. Foster
Professional Engineer

PERTINENT DATA

1. General

Federal ID No.	MT-1455
Owner/Operator	City of Columbia Falls
Date Constructed	1971
Purpose	Water Supply
Location	Sections 27 and 34, T31N, R20W, Principal Meridian
County, State	Flathead County, Montana
Watershed	Cedar Creek, tributary of Flathead River
Downstream Hazard Potential	Category 1 (High)
USGS Quadrangle	Columbia Falls North

2. Reservoir

Drainage Area	12.7 square miles
Surface Area at Principal Spillway Crest (Elevation 3226.5 feet NGVD)	31 acres
Storage at Principal Spillway	390 acre-feet
Storage at Emergency Spillway Crest (Elevation 3243.3* feet NGVD)	1,990 acre-feet
Storage at Dam Crest (Elevation 3246.8* feet NGVD)	2,720 acre-feet
Surcharge Storage (Between emergency spillway crest and top of dam)	730 acre-feet

---

*Elevation based on levels taken at the time of the site visit, using elevation 3226.5 feet NGVD for the crest of the principal spillway

3.	<u>Emergency Spillway</u>	
	Type	Uncontrolled, unlined channel
	Bottom Width	110 feet
	Crest Elevation	3243.3* feet NGVD
	Capacity with Reservoir at Dam Crest	2,150 c.f.s.
4.	<u>Outlet Works/Principal Spillway</u>	
	Type	Uncontrolled, drop inlet with low-level gate
	Conduit	30-inch-diameter reinforced concrete
	Crest Elevation	3226.5 feet NGVD
	Conduit Length	225 feet
	Gate	30-inch-diameter slide gate
	Capacity with Reservoir at Dam Crest	150 c.f.s.
5.	<u>Dam</u>	
	Type	Rolled earth (three fill zones)
	Length	1,220 feet
	Crest Width	20 feet
	Crest Elevation	3246.8* feet NGVD
	Hydraulic Height (Crest to Toe)	50 feet
	Upstream Slope	1 V on 2.5 H
	Downstream Slope	1 V on 2 H

Chapter 1

BACKGROUND

1.1 INTRODUCTION

1.1.1 Authority and Scope

This report summarizes the Phase I inspection and evaluation of the Cedar Creek Dam, owned by the City of Columbia Falls.

The National Dam Inspection Act, Public Law 92-367 dated August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to conduct safety inspections of non-Federal dams throughout the United States. Pursuant to that authority, the Chief of Engineers issued "Recommended Guidelines for Safety Inspection of Dams" in Appendix D, Volume 1 of the U.S. Army Corps of Engineers' report to the United States Congress, National Program of Inspection of Dams, May 1975.

The recommended guidelines were prepared with the help of engineers and scientists highly experienced in dam safety from many Federal and state agencies, professional engineering organizations, and private engineering consulting firms. Consequently, the evaluation criteria presented in the guidelines represent the comprehensive consensus of the engineering community.

Where necessary, the guidelines recommend a two-phase study procedure for investigation and evaluation of existing dam conditions, so deficiencies and hazardous conditions can be readily identified and corrected. The Phase I study is:

(1) a limited investigation to assess the general safety condition of the dam.

(2) based upon an evaluation of the available data and a visual inspection.

(3) performed to determine if any needed emergency measures and/or additional studies, investigations, and analyses are necessary or warranted.

(4) not intended to include extensive explorations and analyses or to provide detailed alternative correction recommendations.

The Phase II investigation includes all additional studies necessary to evaluate the safety of the dam. Included in Phase II, as required, should be additional visual inspections, measurements, foundation exploration and testing, material testing, hydraulic and hydrologic analyses, and structural stability analyses.

The authority for the Corps of Engineers to participate in the inspection of non-federally owned dams is limited to Phase I investigations, except in situations of extreme emergency. In these cases, the Corps may proceed with Phase II studies, but only to the extent needed to answer questions relating to dam safety that cannot otherwise be answered. The two phases of investigation outlined above are intended only to evaluate project safety and do not encompass in scope the engineering required to perform design or corrective modification work. Recommendations contained in this report may be for either Phase II safety analyses or detailed design study for corrective work.

The responsibility for implementation of these Phase I recommendations rests with the dam owner and the State of Montana. It should be noted that nothing contained in the National Dam Inspection Act, and no action or failure to act under this Act, shall be construed (1) to create liability in the United States or its officers or employees for the recovery of damage caused by such action or failure to act or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

1.1.2 Purpose

The purpose of the inspection and evaluation is to identify conditions that threaten public safety, so that they may be corrected in a timely manner by non-Federal interests.

1.1.3 Inspection

The findings and recommendations in this report are based on a brief visual inspection of the project and a detailed review of available construction plans. Inspection procedures and criteria are those established by the "Recommended Guidelines for Safety Inspection of Dams" (Ref. 1).

Personnel present during the October 31, 1979, inspection included:

Richard Eckerlin, Seattle District Corps of Engineers

Art Taylor, State of Montana, Department of Natural Resources and Conservation
Lee Hofferber, U.S. Soil Conservation Service
John R. Floden, City of Columbia Falls
Robert W. Clarke, City of Columbia Falls

CH2M HILL personnel who participated in the field inspection and contributed to this report are:

Miles Bubenik, Geotechnical Engineer, Team Leader
Jerry Jacksha, Geotechnical Engineer
Loren Bottorff, Hydrologist/Hydraulics Engineer

Other CH2M HILL personnel contributing to the report but not attending the field inspection are:

Bob Vilker, Hydrologist/Hydraulics Engineer

This report has been reviewed by the State of Montana Department of Natural Resources and Conservation (DNRC), the U.S. Soil Conservation Service, and the City of Columbia Falls, and their written comments are enclosed at the end of the report.

1.2 DESCRIPTION OF PROJECT

1.2.1 General

Cedar Creek Dam is located on Cedar Creek, a tributary of the Flathead River, in Flathead County, Montana. The dam is approximately 3 miles northeast of Columbia Falls (see Plate 1). The dam's current Federal identification number is MT-1455. The dam was completed in 1971. Cedar Creek Dam is 50 feet high, 1,220 feet long, and impounds approximately 2,720 acre-feet at dam crest elevation 3246.8 feet NGVD. Based on visual reconnaissance and engineering judgment, approximately ten homes on the outskirts of Columbia Falls, an aluminum plant, a lumber mill, the Burlington Northern Railroad tracks, a county road, and portions of the City of Columbia Falls could be affected by a sudden breach of the dam. On the basis of this information and in accordance with the recommended guidelines, the project is intermediate in size, and the downstream hazard potential is high (Category 1).

The 31-acre reservoir is used for municipal water supply and flood protection. The reservoir is the principal water supply for the City of Columbia Falls; the city also has three wells. Public access is prevented by a locked gate across the access road. The project was designed by the U.S. Soil Conservation Service and is owned and operated by the City of Columbia Falls.

The low-level outlet and the principal spillway are combined into a single structure located near the right abutment of the dam (Plate 2). The principal spillway has a 6-foot by 4-foot entrance that transitions to a 4-foot by 4-foot uncontrolled concrete drop inlet and connects to a 30-inch-diameter concrete discharge conduit through the dam. The low-level outlet consists of a slide gate-controlled, 30-inch-diameter concrete conduit that connects to the bottom of the principal spillway riser. The emergency spillway is a 110-foot-wide, grass-lined earth channel on the left abutment of the dam.

1.2.2 Regional Geology and Seismicity

Cedar Creek Dam is situated in a region underlain by Belt Series (Supergroup) strata of Precambrian age. The dam lies in an ice-scoured reentrant at the south end of the Whitefish Range. The reentrant is part of the Rocky Mountain Trench and is bordered on the east by Belt rocks. The Belt Series is a thick conformable sequence of marine clastic and carbonate metasediments. The western flank of Teakettle Mountain, which is adjacent to the dam, is composed of quartzites and argillites of the Ravalli Group and limestones of the Piegan Group of the Belt Series.

Several large faults with vertical displacements, measured in thousands of feet, border on the east side of the trench. Topographic expression at the foot of Teakettle Mountain indicates a north to northwest striking fault, with freshness of the topographic expression suggestive of recent movement. The Rocky Mountain Trench was the site of a major continental ice lobe during the Pleistocene. Cordilleran ice advanced south from British Columbia and covered the land surface to about elevation 5,000 feet near Kalispell, Montana. The trench is partly filled with glacial deposits and some Tertiary silt and gravel. Cedar Creek Dam lies in a reentrant that is floored with deltaic morainal deposits consisting mostly of gravel.

The dam lies in a seismically active area associated with the northern end of the Inter Mountaine Seismic Belt. The Inspection Guidelines Zoning Map shows the site located in Zone 2, which has a potential for moderate earthquake damage. Algermissen (1976) estimates that a 90 percent probability of exceeding a 0.1g acceleration will occur in any 50-year period in the area of the dam. From the viewpoint of geologic structure and historic seismicity, the fault block adjacent to Cedar Creek Dam should be considered as a potential source of strong seismic motion and capable of producing accelerations of damaging proportions to liquefiable foundations and materials.

1.2.3 Site Geology

Cedar Creek Dam is founded on glacial deposits. Preconstruction borehole logs, drilled beneath the embankment, show coarse-grained glacial sediments as much as 80 feet thick overlying glaciolacustrine clays. Drill logs show the materials to consist of unconsolidated mixtures of clay, silt, sand, and gravel.

Both abutments are in glacial materials. Preconstruction boreholes drilled on the abutments show coarse granular materials overlying clay. The right (west) abutment is composed mostly of silty and clayey gravel. One borehole drilled at the east end of the dam encountered bedrock at approximately elevation 3165 feet, or about 75 feet below the natural ground surface. The configuration of the bedrock surface beneath the dam is unknown. Several other boreholes were drilled below elevation 3165 feet and encountered clay. A fault that strikes northwest and follows along the foot of Teakettle Mountain may be under or adjacent to the left abutment and may be active.

1.2.4 Design and Construction History

The Cedar Creek project was designed in 1968 and 1969 by the Soil Conservation Service. Construction for the SCS was completed in 1971. As-built plans, as well as extensive project construction, inspection, and geotechnical data, were available and on file with the SCS. All plates included in this report, except Plates 1 and 5, were reproduced from SCS construction drawings. Stability analysis of the embankment is on file with the SCS.

Chapter 2

INSPECTION AND RECORDS EVALUATION

2.1 HYDRAULICS AND STRUCTURES

2.1.1 Emergency Spillway

The emergency spillway for Cedar Creek Dam is located in natural ground of the left abutment. The spillway consists of a grass-lined earth channel approximately 1,300 feet long and 110 feet wide (Plate 3). Spillway control is located at an earth weir with a 30-foot breadth at elevation 3243.3 feet NGVD. This elevation is based on levels taken at the time of the site visit and using elevation 3226.5 NGVD (from as-builts) for the crest of the principal spillway. Therefore, the crest of the emergency spillway is assumed to be 0.3 feet higher than shown on the construction plans. The crest of the emergency spillway is 3.5 feet below the low point on the dam crest, about 2 feet above the approach channel, and about 3 feet above the discharge channel.

The 110-foot-wide, grass-lined approach channel is about 200 feet long (Photo 1). The channel has an adverse slope of 0.01 from the reservoir to the spillway crest (Plate 4). The 110-foot-wide grass-lined discharge channel is about 1,100 feet long. The discharge channel makes a 42 degree, 409.3-foot-radius bend to the right (looking downstream) beginning about 100 feet downstream of the crest. The channel has a slope of 0.04 for approximately 100 feet downstream of the crest and 0.002 for approximately another 400 feet. Near the downstream end of the bend, the channel begins to turn into a natural ravine. The ravine reenters the Cedar Creek valley bottom about 1,800 feet downstream of the spillway crest. A trail dike was constructed along the right side of the channel from the crest to a point about 700 feet downstream of the crest.

The spillway is in very good condition, but it has never been operated. The channel may experience some erosion when it operates but this erosion is not expected to be severe. There are some small trees growing in the spillway channel.

The emergency spillway discharge rating was developed by assuming that critical depth occurs at the crest section. Backwater computations were made in the approach channel with a Manning's "n" of 0.03. The maximum discharge capacity of the spillway with the reservoir at assumed top of dam, elevation 3246.8 feet NGVD, was estimated to be 2,150 c.f.s. The emergency spillway rating curve is presented on Plate 5.

2.1.2 Principal Spillway

The principal spillway and low-level outlet works (Plate 6) at Cedar Creek Dam discharge through a common conduit that passes through the dam near the right abutment (Photo 2). The principal spillway consists of an uncontrolled concrete drop-inlet riser.

The top of the riser is at elevation 3226.5 feet NGVD, which is 20.3 feet below the low point on the dam crest. The as-built drawings show that the riser is 31 feet tall and has inside dimensions of 4 feet by 4 feet with an entrance 6 feet by 4 feet. A 10-inch-wide concrete anti-vortex wall, at the centerline of the riser, extends 3.5 feet above the top of the riser and 3 feet below the top of the riser. The top 3 feet of the riser has a slight flair to allow more flow area. The two sides of the riser that are parallel to the anti-vortex wall slope away from the wall at 3 V on 1 H (see Plate 7).

A 30-inch-diameter concrete discharge conduit extends 170 feet on a slope of 0.01 to the impact type stilling basin at the toe of the dam. The basin appears to adequately dissipate energy of the conduit discharge. Discharges from the stilling basin make a 75-degree bend to the left and enter a 10-foot-wide riprapped channel that extends along the toe of the dam (Plate 2). About 50 feet downstream of the stilling basin the channel is crossed by a 4-foot-wide concrete wasteway inlet. A 24-inch-diameter CMP conduit extends through the channel bank to carry water to the sediment basin. The conduit is fitted with a slide gate, but the gate is currently inoperable because of a bent gate frame and a broken gate wheel. The sediment basin was used during the construction period. A section of the basin's embankment was removed in early 1979 to prevent the basin from storing significant amounts of water. Currently, small discharges from the stilling basin are intercepted by the wasteway, enter the sediment basin, and continue through the breached embankment to Cedar Creek. Higher discharges, which are not intercepted by the wasteway, continue in the diversion channel along the toe of the dam to an existing diversion channel. The channel is well riprapped so flows will not endanger the dam.

The drop inlet riser is fitted with a trashrack formed of pipe. The riser is also protected by a log boom. Since the riser is at the upstream face of the dam, a simple supported log boom could not be used. Several logs were used to form a truss to surround the riser. The ends of four of the logs are anchored with concrete blocks set on the face of the dam. Some of the logs are partially submerged, which could

allow floating debris to pass to the spillway riser. This will cause the riser trashrack to become easily clogged.

The discharge conduit was not inspected during the site visit because of its small size and because of water entering from the low-level outlet. The riser was not inspected because of access problems.

The discharge rating of the principal spillway was computed by combining ratings for weir control at the top of the riser and full conduit flow. The lip of the riser was assumed to operate as a weir with a discharge coefficient of 3.33. A Manning's "n" of 0.013 was used to compute friction losses for full flow conditions. The control was found to change from weir flow to full conduit flow when the reservoir level rises more than 1.7 feet above the top of the riser. The maximum spillway discharge with the reservoir level at the top of dam, elevation 3246.8 feet NGVD, was estimated to be 150 c.f.s.

2.1.3 Outlet

The low-level outlet works consists of a 30-inch-diameter concrete conduit and slide gate. The conduit connects to the bottom of the principal spillway riser and the flows continue to the discharge conduit used for principal spillway flows (see paragraph 2.1.2). The conduit is 55 feet long from the intake structure to the riser. The construction plans show the intake structure is a reinforced concrete monolith consisting of wing walls, head wall, floor, cutoff wall, and a trash rack. The gate is located in a small closed well on the side of the riser. The gate is operated by use of a gate lift located on top of the principal spillway anti-vortex wall.

The discharge rating was developed with the gate open and by assuming full conduit flow with Manning's "n" of 0.013. The maximum discharge with the reservoir at principal spillway elevation 3226.5 feet NGVD was estimated to be 140 c.f.s.

In addition to the low-level outlet works, the dam is fitted with a 16-inch-diameter municipal water supply line. The water supply line has two steel inlet pipes controlled by butterfly valves on the upstream side of the dam. The two pipes are at different elevations so water can be selected on the basis of quality. The two pipes merge to a single concrete pipe. The conduit extends through the embankment alongside the principal spillway discharge conduit. Additional valves are located on the line downstream of the dam. The line continues to a chlorine house at the toe of the dam and on to the city water system. The line was designed to

operate pressurized. Therefore, regular inspections of the interior of the conduit would minimize the potential for a leak, causing a piping failure of the dam.

2.1.4 Freeboard

Flood routings (see paragraph 2.2.4) indicate that the dam overtops during the PMF; therefore, the dam has no freeboard. The vertical distance between the low point on the dam crest and the reservoir level at the time of the October 31, 1979 inspection was 21.9 feet. The crest of the principal spillway is 20.3 feet below the low point on the dam crest, and the crest of the emergency spillway is 3.5 feet below the low point on the dam crest. The crest of the dam varies approximately 1 foot in elevation along its 1,220-foot length. The effective fetch for wind-generated waves on the reservoir is less than one-half mile with the reservoir at the emergency spillway crest. Wave runup on the embankment is estimated to be less than 3 feet. Although the dam will overtop during the PMF, the vertical distance between the crest of the dam and the normal reservoir level is adequate to prevent overtopping of the embankment by wind-generated waves. According to Mr. Clarke of the City of Columbia Falls, the maximum reservoir level observed since the dam was constructed was near the top of the principal spillway anti-vortex wall. This is about 17 feet below the low point on the dam crest.

2.2 HYDROLOGY, CLIMATOLOGY, AND PHYSIOGRAPHY

2.2.1 General

The climate of the area is modified continental, characterized by warm summers, cold winters, and a semiarid precipitation regime. There are several precipitation and temperature stations in the area. Mean annual precipitation at Whitefish (elevation 3060 feet NGVD), about 7 miles northwest of Cedar Creek Dam, is 23.15 inches. Mean monthly precipitation at Whitefish varies from a low of 1.18 inches in July to a high of 3.38 inches in June. Mean annual precipitation on the Cedar Creek drainage may be near 30 inches. Mean annual temperature at Kalispell (elevation 2965 feet NGVD), about 12 miles southwest of the dam, is 44 degrees Fahrenheit (F). Mean monthly temperature at Kalispell varies from a low of 21.8 degrees F in January to a high of 66.2 degrees F in July. Temperatures on the Cedar Creek drainage basin may average about 5 degrees cooler than Kalispell.

The drainage basin area for Cedar Creek Dam is 12.7 square miles and is on the west slope of the Continental Divide. The basin is roughly rectangular in shape, with the width equal to about 40 percent of the length. Basin elevations

range from 3240 feet NGVD at the dam to 5830 feet NGVD on the northern boundary of the basin. The basin is steep and heavily forested. There are no streamflow gages on Cedar Creek or on any nearby streams. There is a parshall flume on the diversion channel at the toe of the dam, but most outlet flows are intercepted by the wasteway just upstream of the flume.

2.2.2 Reservoir Storage and Spillway Discharge

The reservoir has a surface area of 31 acres and a storage of about 390 acre-feet at principal spillway crest, elevation 3226.5 feet NGVD. The reservoir has a storage of about 1,990 acre-feet at emergency spillway crest, elevation 3243.3 feet NGVD. Approximately 730 acre-feet surcharge storage is available in the reservoir between the emergency spillway crest and the dam crest. The emergency spillway discharge with the reservoir at the dam crest was estimated to be 2,150 c.f.s., about 180 acre-feet per hour. The principal spillway discharge with the reservoir at the dam crest was estimated to be 150 c.f.s., about 12 acre-feet per hour.

2.2.3 Estimated Probable Maximum Flood

The inspection guidelines recommend that the spillway design flood for a project of this type be the probable maximum flood (PMF). The PMF is the flood expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. A severe storm with intensities approaching that of the PMF occurred over the Continental Divide, about 40 miles east of Cedar Creek Dam, in June 1964.

Procedures available for the area west of the Continental Divide allow for development of a PMP from a thunderstorm or a general storm. Because of the Cedar Creek Dam drainage basin size, a thunderstorm was believed to cause the most critical flood. The procedures contained in Hydrometeorological Report No. 43 (Ref. 2) and the Weather Bureau's 1967 memo (Ref. 3) were used to compute the thunderstorm PMP. The memorandum allows for some reduction of the PMP that was not originally contained in Report No. 43.

The July thunderstorm PMP produces 5.8 inches in 1 hour and 8.2 inches in 6 hours for the 12.7-square-mile drainage basin. Because of the high intensity rainfall and the possibility of near saturated soil conditions from thunderstorms on preceding days, a constant 0.15-inch-per-hour loss was assumed during the thunderstorm PMP. A triangular unit hydrograph for 15-minute rainfall duration was developed for

the 12.7-square-mile drainage basin by procedures outlined in Design of Small Dams (Ref. 4). A curvilinear fit of the triangular unit hydrograph was used. The PMP was applied to the unit hydrograph by means of the computer program, HEC-1 (Ref. 5). This estimate of the PMP produced a flood with a peak flow of 34,000 c.f.s. and a volume of 4,930 acre-feet.

2.2.4 Flood Routing

The PMF was routed through the reservoir by using the computer program HEC-1 (Ref. 5). It is possible for major storms to occur a few days prior to the PMF. The routing of the PMF was started with the reservoir about 8 feet below the emergency spillway crest. This level was roughly estimated as a possible reservoir level after a 100-year rainfall of 1.9 inches over the basin. The actual 100-year reservoir level may be near the emergency spillway crest, since the SCS used a snowmelt flood to design the emergency spillway to operate slightly less than once in 100 years.

Routing studies indicated that:

- During the full PMF, the dam would be overtopped when approximately 44 percent of the flood volume enters the reservoir.

- Routings were made of lesser hypothetical floods than the PMF to determine the magnitude of floods the dam can contain. The hypothetical hydrographs are obtained by applying percentages to the PMF ordinates. A flood with a hydrograph having ordinates corresponding to 45 percent PMF ordinates is just controlled by the project. Larger floods would overtop the dam.

2.3 GEOTECHNICAL EVALUATION

2.3.1 Dam Embankment

The 50-foot-high, straight-axis embankment dam is 1,220 feet long and has a crest width of 20 feet. The upstream slope is 1 V on 2.5 H and the downstream slope is 1 V on 2.0 H (Plate 8). Unified soil classification symbols on the embankment sections and laboratory test data indicate that the embankment was designed with a central more impervious zone that is confined by a gravel transition zone. Gradation tests indicate the transition zone material is graded to perform as a filter. The shell material (Zone III) was observed to be well-graded subrounded gravels. The upstream slope (Photo 3) was 12-inch minus gravel, and the downstream slope (Photo 4) was similarly sized except for an approximately

20-foot band of large cobbles at midslope. The upstream slope is adequately protected from wave erosion by the gravel fill.

The slopes have a sparse covering of grass and brush. The dam is constructed of materials that would quickly erode and rapidly fail when overtopped by flood waters. The upstream slope has experienced some minor erosion near midslope at the elevation of the principal spillway. No significant erosion, irregularities, slumps, or cracks were found on the dam crest or slopes.

2.3.2. Foundation Conditions, Seepage, and Drainage

According to the as-built drawings, the entire dam foundation was stripped to a depth of at least 2 feet. Both abutment foundations are in recessional moraines consisting of sands, gravels, and boulders. A cutoff trench was constructed under the central core along the dam axis centerline for the entire length. The boring logs on Plate 9 indicate that the cutoff was carried into silty gravels (GM) along the left portion of the dam and into clays (CL) in the center portion where the maximum cutoff depth is 25 feet. Along the right abutment, the plans show the cutoff between stations 24+00 and 28+00 extended 10 to 15 feet below the deepest boring. Materials and methods used to backfill the cutoff trench are well documented; gradation tests on embankment materials are available.

As-built plans indicate that a granular transition (filter) and drain were placed downstream of the cutoff, as shown on Plate 8.

During the inspection (pool elevation 3225 feet NGVD), no embankment seepage was observed; however, a wet spot was noticed 10 feet downstream of the toe near the left abutment in the area of the old stream channel. No seepage was noticed in the side slopes of the 10-foot-deep diversion ditch that runs along the entire length of the downstream toe. Seepage and erosion were observed approximately 200 feet downstream of the dam in the right abutment cut slope. The seepage emerged about 18 feet above the embankment toe elevation, or about 13 feet below the reservoir level. It is probable that this seepage source is the reservoir. The wet area and seepage observed are not now a threat to embankment stability, but these areas should be monitored on a regular basis, especially during high runoff periods when reservoir levels are above the principal spillway.

There are no piezometers installed in the dam.

2.3.3 Stability

Stability analyses for static and seismic loading conditions are on file with the SCS.

Based on a review of available information, it is our judgment that embankment stability conforms with the recommended guidelines. However, a check of embankment stability using water level data obtained from piezometric observations is necessary.

2.4 PROJECT OPERATION AND MAINTENANCE

Cedar Creek Dam is owned and operated by the City of Columbia Falls. There is no formal operation and maintenance program for the facility. Information about operations and maintenance was obtained through discussions with Mr. Clark of the City of Columbia Falls.

2.4.1 Dam

Maintenance of the dam is performed as required. The dam appeared to be very well maintained, with the exception of small trees growing in the emergency spillway and the partially submerged condition of the log boom for the principal spillway.

2.4.2 Reservoir

The reservoir is used primarily for storage of water for municipal use, but the reservoir also provides some flood control. The dam is visited daily by someone from the City of Columbia Falls, since the chlorination house for the city water supply is located at the toe of the dam. The city does not perform any operation of the reservoir. The 16-inch-diameter water supply line removes water from the reservoir as required by use in the city.

The gate on the low-level outlet was slightly open and passing water to Cedar Creek at the time of the site visit. Mr. Clarke indicated that he had no knowledge of that gate setting ever being changed. The reservoir normally remains within a few feet of elevation throughout the year. The partially open low-level outlet may lower the reservoir a few feet below the spillway riser before new basin runoff raises the reservoir above the principal spillway riser. The uncontrolled spillway riser normally keeps the reservoir from rising more than a few feet above the riser lip.

2.4.3 Warning System

There is no formal warning plan for use in the event of impending dam failure.

Chapter 3

FINDINGS AND RECOMMENDATIONS

3.1 FINDINGS

Visual inspection of the dam, supplemented by analysis of the project in terms of the recommended guidelines performance standards, resulted in the following findings.

3.1.1 Size, Hazard Classification, and Safety Evaluation

In accordance with inspection guidelines, Cedar Creek Dam is intermediate in size, with a high downstream hazard potential rating. The guidelines recommend that a dam with the above classification be capable of safely handling a spillway design flood of 100 percent of the PMF. Because the project is incapable of controlling the PMF without overtopping and causing the dam to fail, Cedar Creek Dam does not meet inspection guidelines.

3.1.2 Embankment Dam

A visual inspection of the dam revealed no longitudinal or transverse cracking and no embankment seepage. Seepage, which does not now affect embankment stability, was observed about 200 feet downstream of the embankment toe on the right abutment. A small wet area was observed 10 feet downstream of the toe near the left abutment.

The upstream and downstream slopes were uniform, with no irregularities. The downstream slopes support a very sparse covering of grass and small brush. Gravels on the upstream slope adequately protect against erosion, and the normal freeboard is adequate to prevent wind-generated waves from overtopping the dam crest.

No piezometers are installed in the dam. Based on a review of as-built plans, design investigations, available laboratory testing, and stability analyses, it is our judgment that embankment stability conforms with the recommended guidelines. However, a check of the stability based on observed water levels is necessary.

3.1.3 Spillway and Reservoir Capacity

The reservoir has a surface area of 31 acres and a storage of about 320 acre-feet at principal spillway crest. The reservoir has a storage of about 1,530 acre-feet at the

emergency spillway crest. Approximately 510 acre-feet of surcharge storage is available in the reservoir between the emergency spillway crest and the dam crest. The emergency spillway discharge with the reservoir at the dam crest was estimated to be 2,150 c.f.s. The principal spillway discharge with the reservoir at the dam crest was estimated to be 150 c.f.s. Some small trees are growing in the emergency spillway.

It appears that the vertical riser (principal spillway) conduit will not prevent a full-flow (pressurized) condition when the reservoir pool is approximately at or above elevation 3228 feet NGVD. Consequently, it is possible that the conduit would be pressurized for several days while a flood event is being accommodated. This results in a pressurized conduit through the earthen embankment with no means for emergency closure at the upstream end.

3.1.4 Outlet Works

Neither the outlet conduit nor the principal spillway riser was inspected during the site visit. The low-level outlet gate may not have been operated since the dam was completed and may be or become inoperable if left unused.

3.1.5 Operation and Maintenance

The City of Columbia Falls has no operation and maintenance plan for the dam. The City makes no gate settings to control the level of the reservoir. The reservoir normally does not fluctuate more than a few feet in elevation throughout the year. The dam is visited daily by someone from the City of Columbia Falls, and maintenance is performed as required. There is no formal warning plan for use in the event of impending dam failure.

3.2 RECOMMENDATIONS

Due to storage between normal pool and dam crest, the present project provides a degree of flood protection to the downstream area. The intent of report recommendations is to maintain or improve project safety, if feasible, while preserving existing flood protection.

The findings suggest that high priority be given to the following recommendations:

1. Immediately develop, implement, and periodically check an emergency plan for alerting downstream residents in case of impending dam overtopping or structural failure.

2. Perform an inspection of the principal spillway riser, low level outlet works, spillway/outlet discharge

conduit, and water supply conduit, and repair as necessary.

3. Clear all trees from the emergency spillway.

4. Operate the low-level outlet gate through at least one full cycle of its operating range annually.

5. Modify the principal spillway system to provide emergency closure.

6. Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and required spillway capacity, and modify the project as studies indicate.

7. Install piezometers in the embankment and right abutment. Determine the source of right abutment seepage and downstream wet area. Monitor seepage and phreatic surface levels as related to reservoir levels.

8. Check embankment stability using water level data from piezometric observations. The studies must be performed by a qualified geotechnical engineer.

9. Conduct periodic inspections of the facility, at least at 5-year intervals, by engineers with experience in dam design and construction.

10. Before performing engineering studies and remedial construction, coordinate the work with the State of Montana DNRC (Office of Dam Safety) to assure compliance with pertinent laws and regulations.

REFERENCES

1. U.S. Army Corps of Engineers, Office of the Chief of Engineers Report to the U.S. Congress, National Program of Inspection of Dams, Vol. 1, Appendix D, "Recommended Guidelines for Safety Inspection of Dams," Washington, D.C., Department of the Army, May 1975.

2. U.S. Weather Bureau, Hydrometeorological Report No. 43, "Probable Maximum Precipitation, Northwest States," Washington, D.C., 1966.

3. U.S. Weather Bureau, Office of Hydrology, MEMO: "Probable Maximum Precipitation, Northwest States," August 21, 1967.

4. U.S. Bureau of Reclamation, Design of Small Dams, 2nd Edition, 1974.

5. U.S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-1 Flood Hydrograph Package, Davis, California, January 1973.

APPENDIX

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
WATER RESOURCES DIVISION

THOMAS L. JUDGE, GOVERNOR

32 SOUTH EWING

STATE OF MONTANA

(406) 449-2872

HELENA, MONTANA 59601

September 19, 1980

Department of the Army
Seattle District, Corps of Engineers
P. O. Box C-3755
Seattle, WA 98124

Attn: Ralph MOrrison

Re: CH2/M Hill Dam Safety Inspection Report on Cedar Creek Dam (MT-1455)

Dear Ralph:

We have reviewed the above referenced final draft report. We concur with the findings and recommendations and find that is satisfies the criteria of Phase I report.

Minor editorial comments have been discussed with your staff, and we understand these will be incorporated in the final report.

Thank you for this opportunity to review and comment on the final draft report on Cedar Creek Dam.

Sincerely,

Richard L. Bondy

Richard L. Bondy, P.E.
Chief, Engineering Bureau
(406) 449-2864

RB/AT/lj

AN EQUAL OPPORTUNITY EMPLOYER

The page numbers referred to in the following two letters changed in the final report:

City of Columbia Falls letter:

page 4	now page 3
page 13	now page 8
page 18	now page 13
page 23	now page 17
page 24	now page 17

Soil Conservation Service letter:

page vi	now page v
page 12	now page 8
page 14	now page 9
page 22	now page 16

CITY OF COLUMBIA FALLS
DRAWER G
COLUMBIA FALLS, MONTANA 59912

September 3, 1980

Department of the Army
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, Washington 98124

Attn: Sidney Knutson, P.E.

Re: Inspection Report
Cedar Creek Dam
Columbia Falls, Montana
Flathead County
MT-1455

Gentlemen:

This letter will constitute the City of Columbia Falls comments on the subject report. In general the report looks very good.

Page 4 - I would estimate 15 to 20 homes would be affected instead of 10.

Page 13 - We found this summer while doing some work on the city intake works that there is only one operable intake at approximately 18 feet below the drop outlet structure. The upper intake had been removed apparently by the city some years ago and a 12 inch pipe was run down from it into the sediment pool in an attempt to obtain better tasting water. The end of this pipe was apparently buried in bottom mud through the passage of time because we, in trying to operate the intake, drew only mud into the system. We have since cut the pipe and are re-piping it to just in front of the bar screen of the lower reservoir outlet, approximate elevation 29 feet below the drop outlet.

Page 18 - Mr. Clarke's name has an "e" on the end.

Page 23 - Operation of the gate on the outlet works. In doing the work we did this summer the lowlevel outlet gate was operated. It worked very well. We opened it so that the normal stem showing above the gate of 3 inches was changed to a stem of 10 inches. The reservoir level dropped from approximately ½ foot above the drop outlet wier to 18 feet below the wier in about 4 days. This exposed the city's intakes for the work we had to do.

Page 24 - The city had YACC crews clear the spillway and diversion channel of all brush and small trees in March of 1980. Clearing was done along the entire length of both of these structures.

I hope that these comments will help you in completing this report. I feel that this report will help the city in doing its part to operate the dam properly.

Sincerely,

John R. Floden, P.E.
Public Works Director

United States Department of Agriculture
Soil Conservation Service
P.O. Box 970
Bozeman, MT
59715

September 9, 1980

Sidney Knutson, P.E.
Assistant Chief
Engineering Division
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, WA 98124

Dear Mr. Knutson:

Thank you for the opportunity to review the final draft report on Cedar Creek Dam (MT-1455).

Our comments relating to specific report statements are:

Page vi, line 5: There is a static stability analysis on file, however, the consultant's representative elected not to reproduce it.

Page 12, line 24: The intake structure is a reinforced concrete monolith consisting of wing walls, head wall, floor, cutoff wall and a trash rack.

Page 14, line 19: Mean annual precipitation on the Cedar Creek drainage is closer to 20 inches. (From SCS and MDNR&C rain and snow data.)

Page 22, last paragraph: SCS criteria precludes the use of a gate on a spillway. A gated outlet is not a spillway. With improper operation, the gate could be closed during a flood event increasing the probability of structure failure over that of a pressurized conduit condition.

We cannot agree with the hydrology criteria used to develop the probable maximum flood.

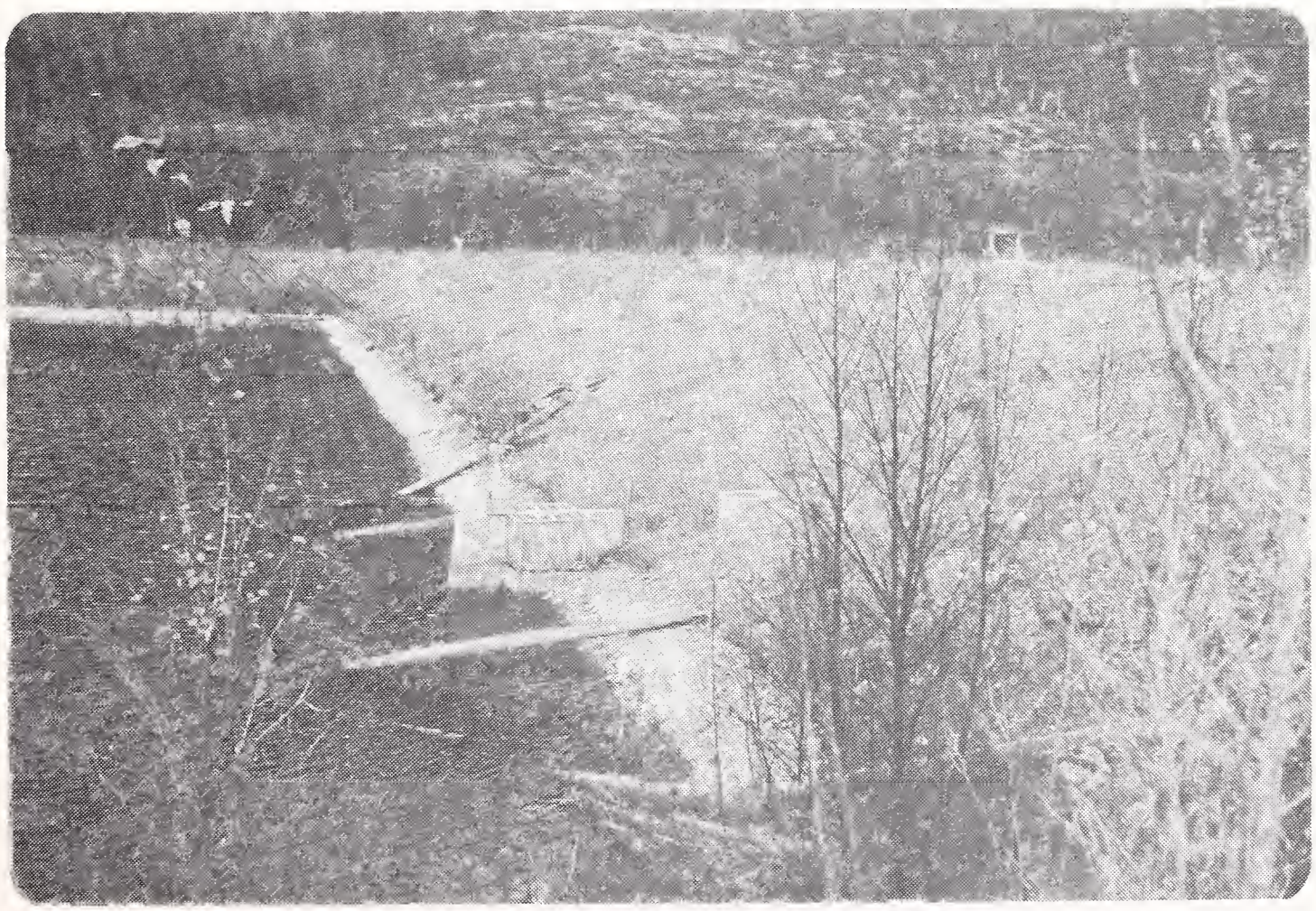
Sincerely,

Van K Haderlie

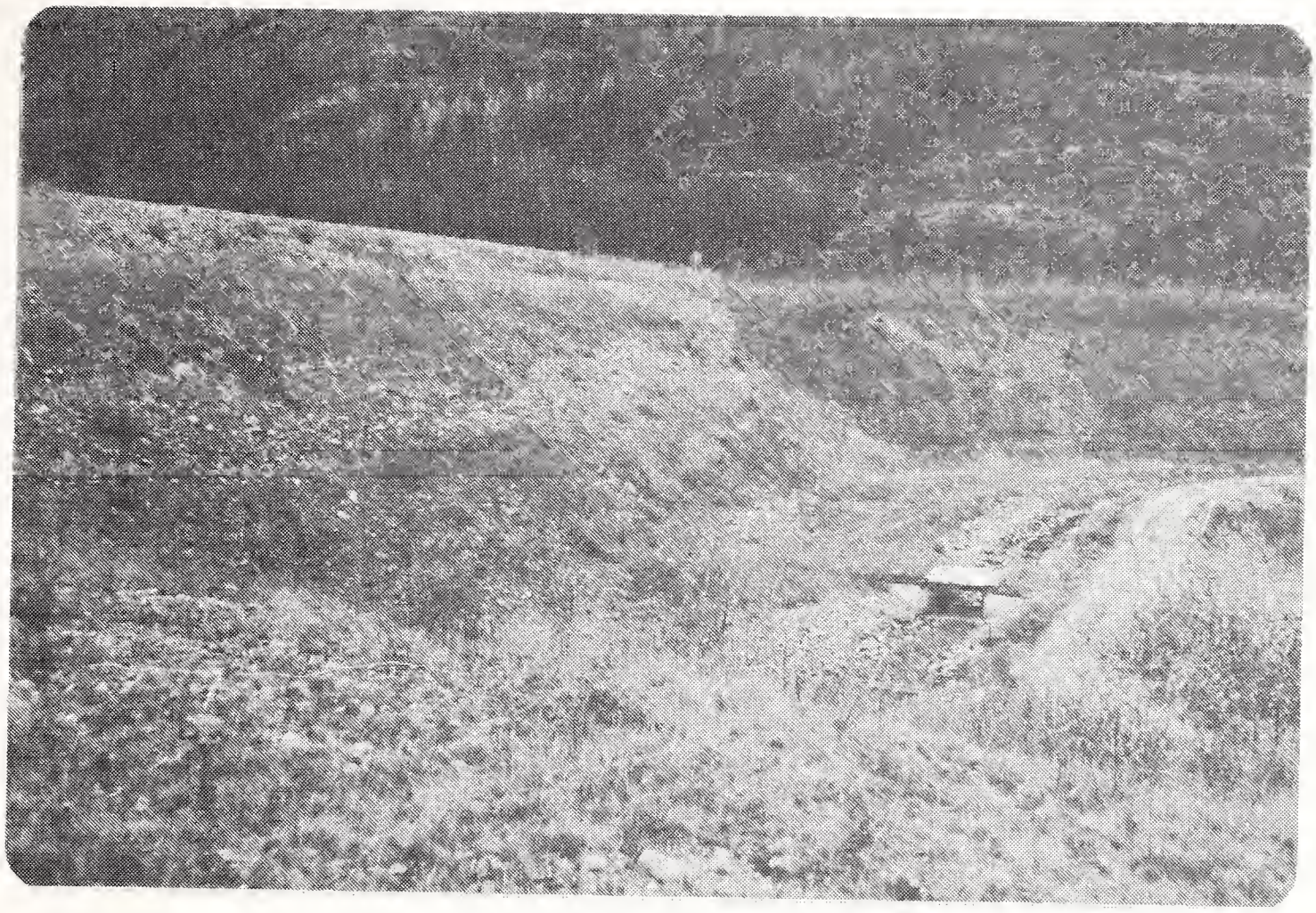
Van K Haderlie
State Conservationist

cc:
Homer C. Moore, SCE, SCS, Bozeman
Dave Jones, EE, SCS, Bozeman

(PHOTO 1) SPILLWAY APPROACH CHANNEL

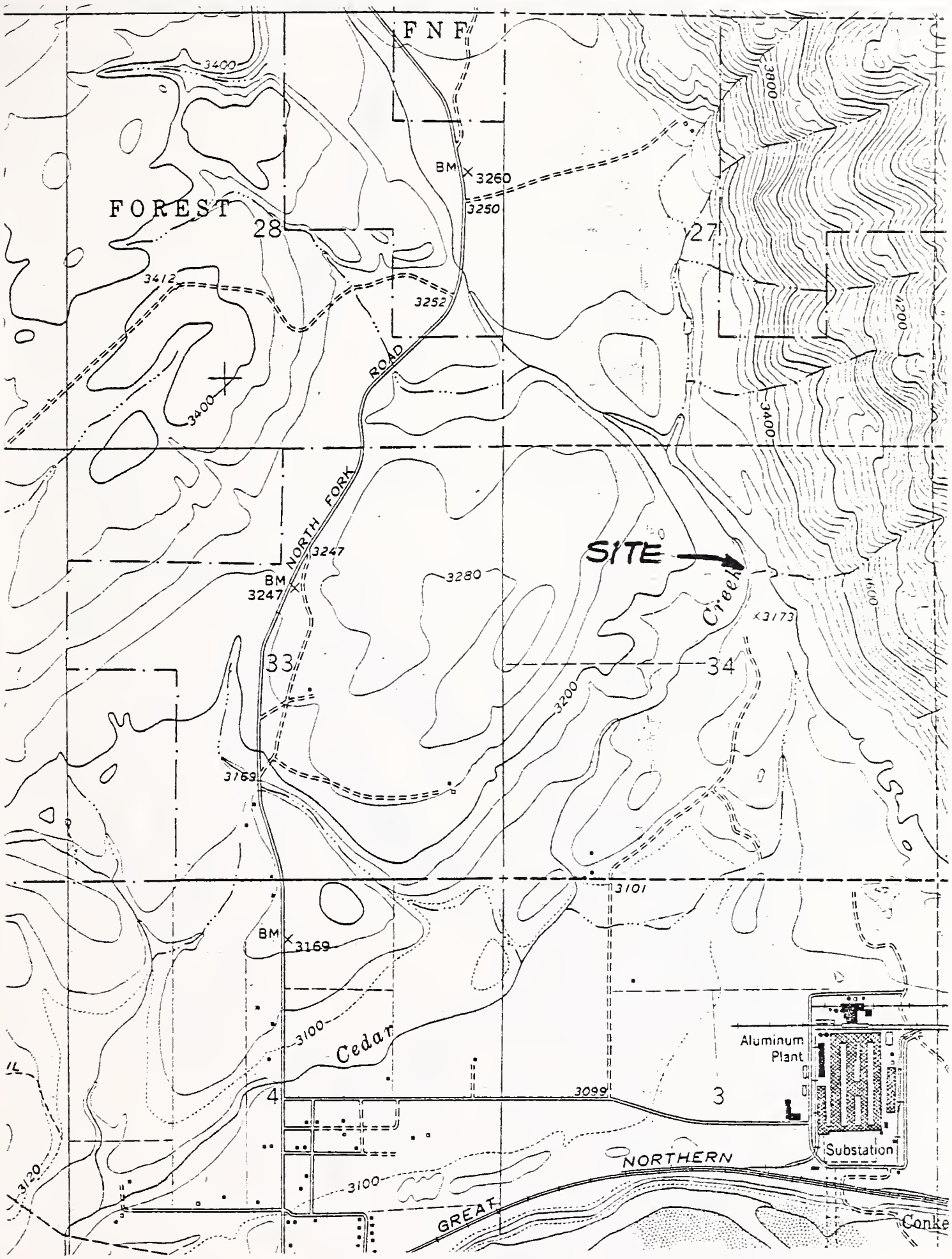


(PHOTO 2) EMBANKMENT UPSTREAM SLOPE AND PRINCIPAL SPILLWAY



(PHOTO 3) EMBANKMENT DOWNSTREAM SLOPE

(PHOTO 4) SEEPAGE AREA - DOWNSTREAM ON RIGHT ABUTMENT



0 1/2 1 Mi

SCALE = 1: 24000

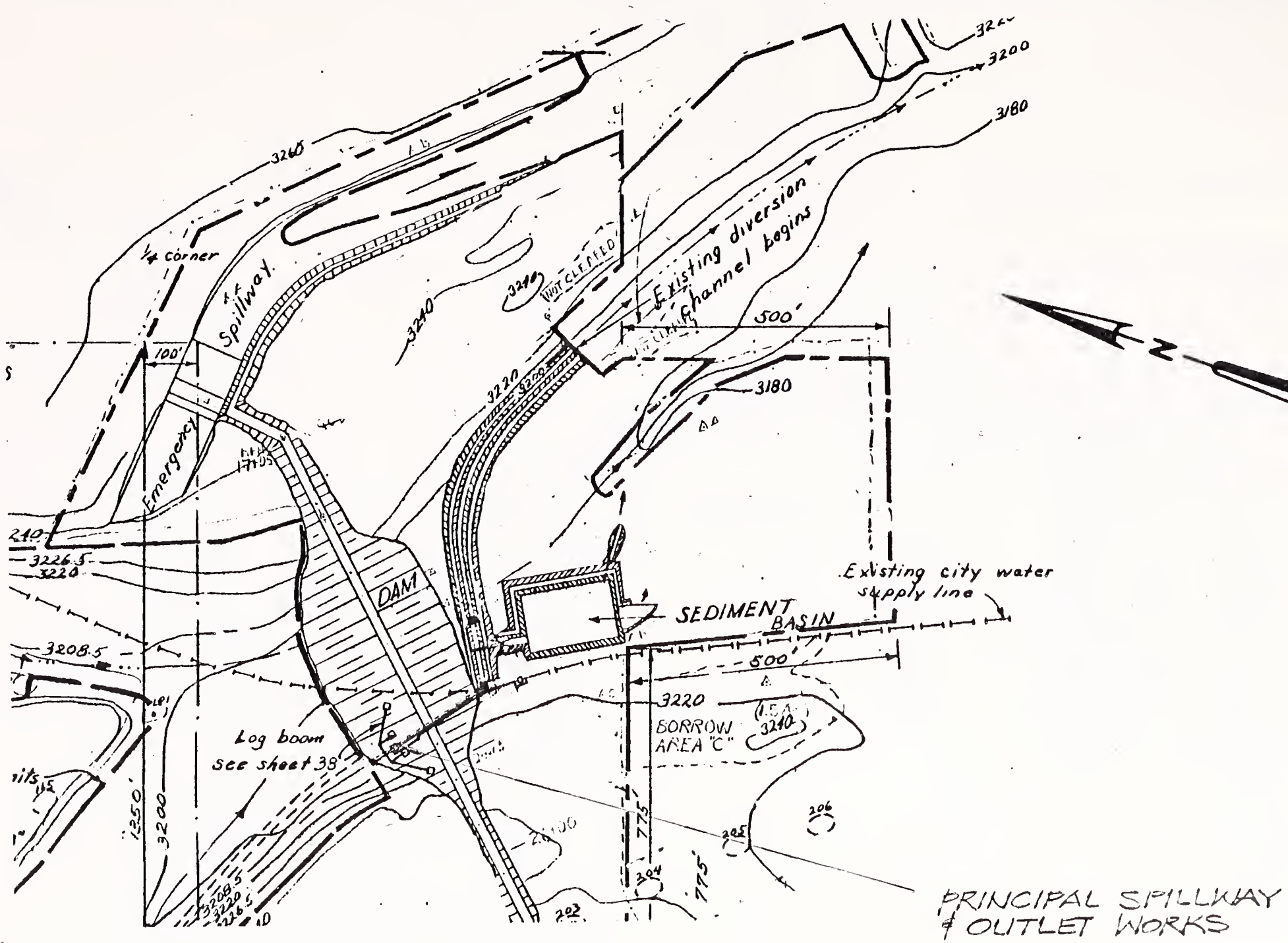
N

PLATE 1

CEDAR CREEK DAM

VICINITY MAP

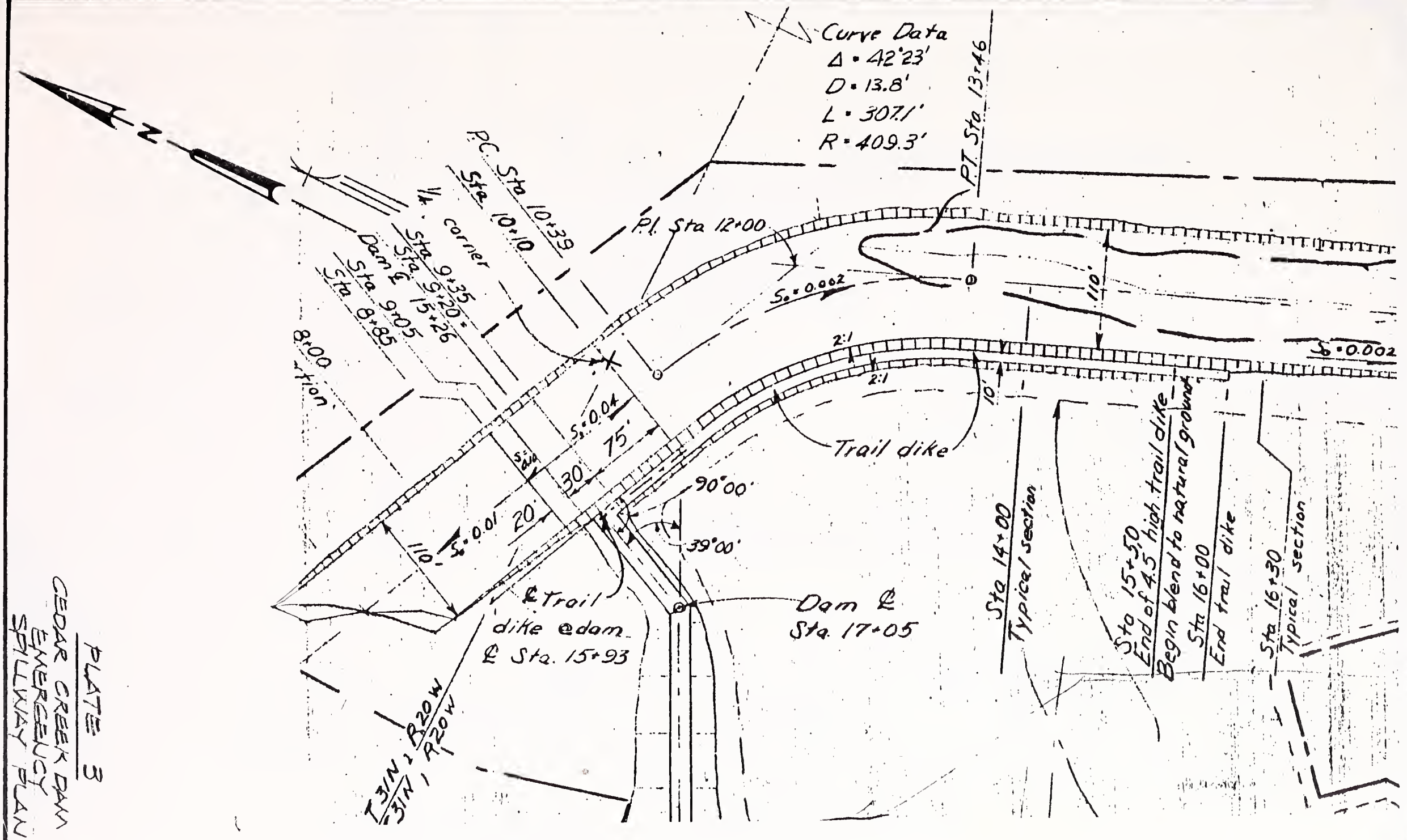
CH2M HILL



PLAN
H.T.S.

PLATE 2
CEDAR CREEK DAM
SITE PLAN

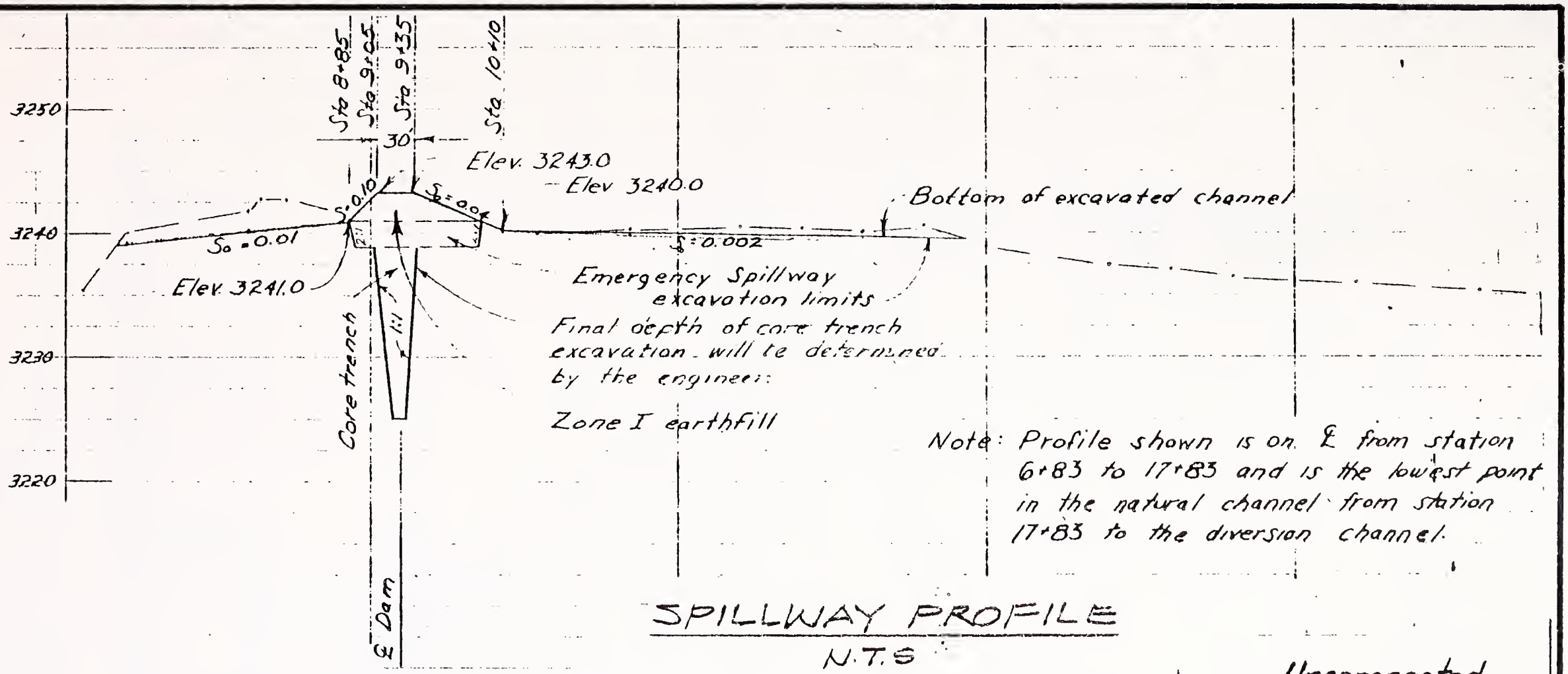
CH2M HILL



PLAN
N.T.S.

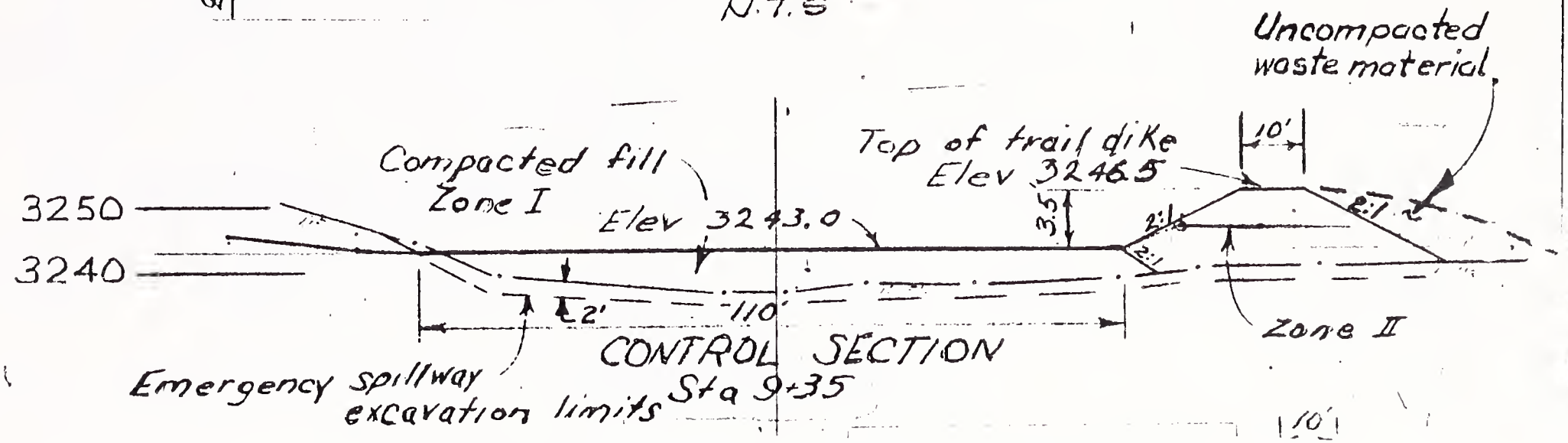
PLATE 3
CEDAR CREEK DAM
EMERGENCY
SPILLWAY PLAN

CH2M HILL



SPILLWAY PROFILE

N.T.S



TYPICAL SPILLWAY SECTION

N.T.S

PLATE 4

CEDAR CREEK DAM

EMERGENCY SPILLWAY

PROFILE & SECTION

CH2M HILL

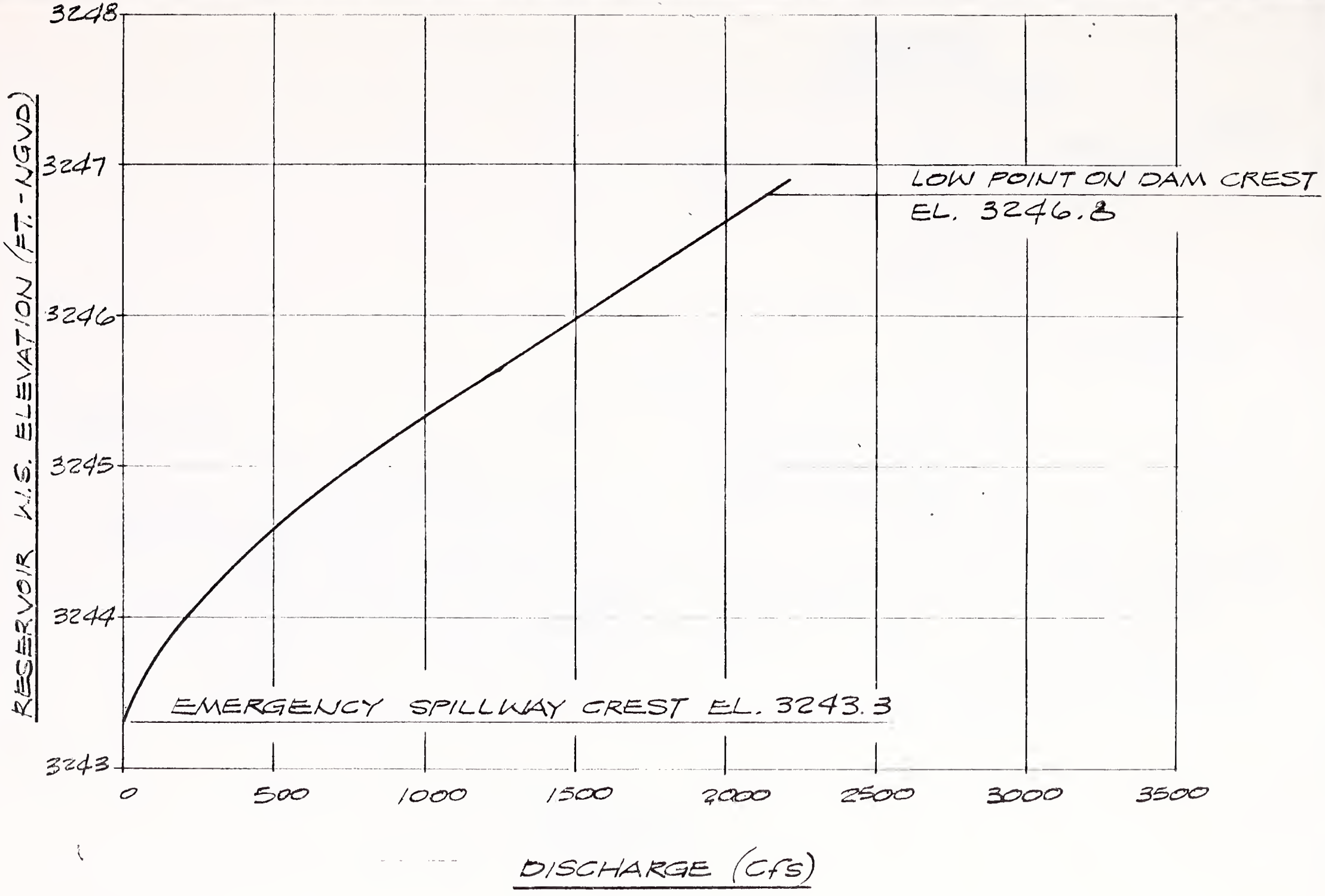
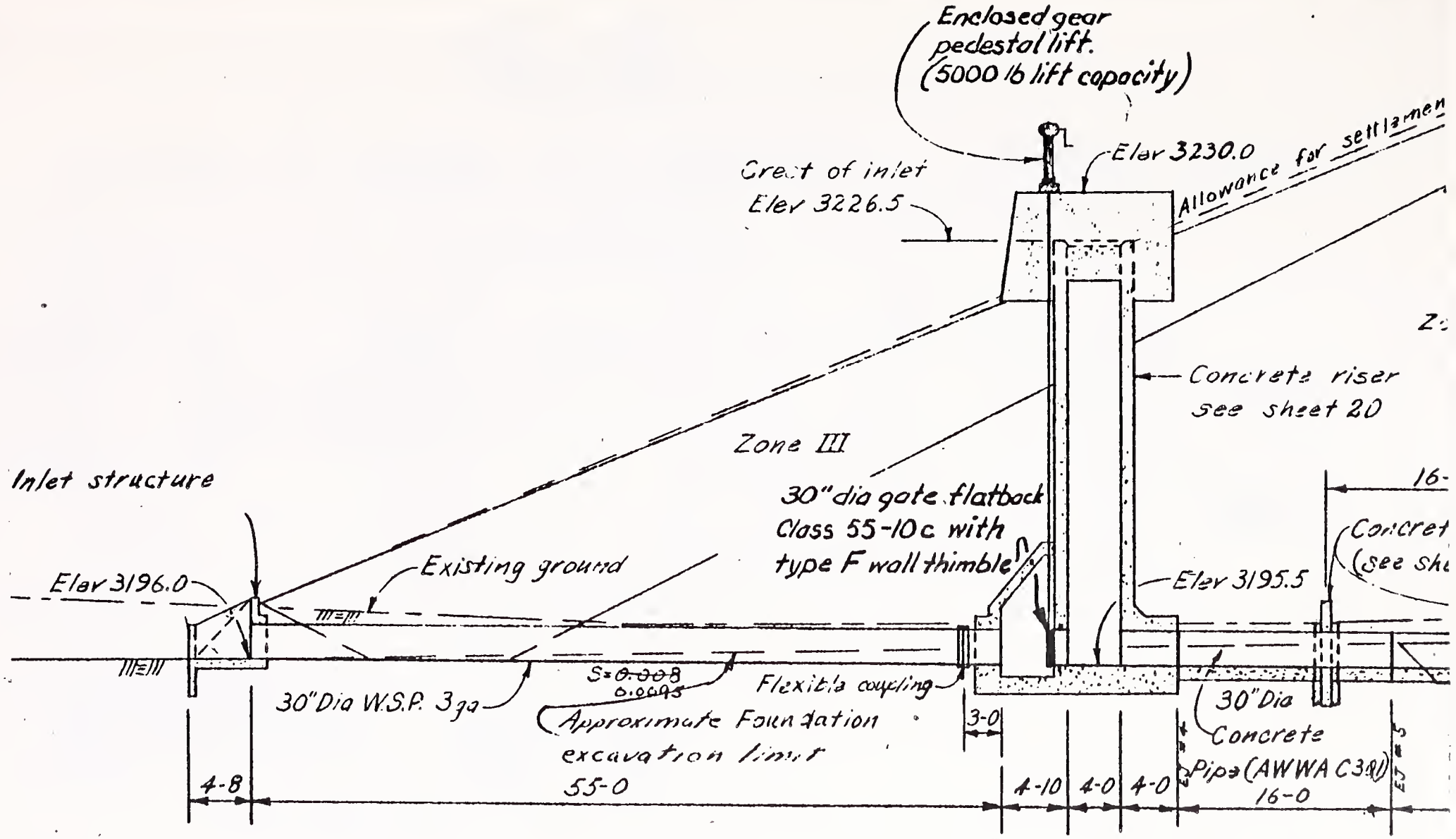


PLATE 5

CEDAR CREEK DAM

EMERGENCY SPILLWAY RATING CURVE

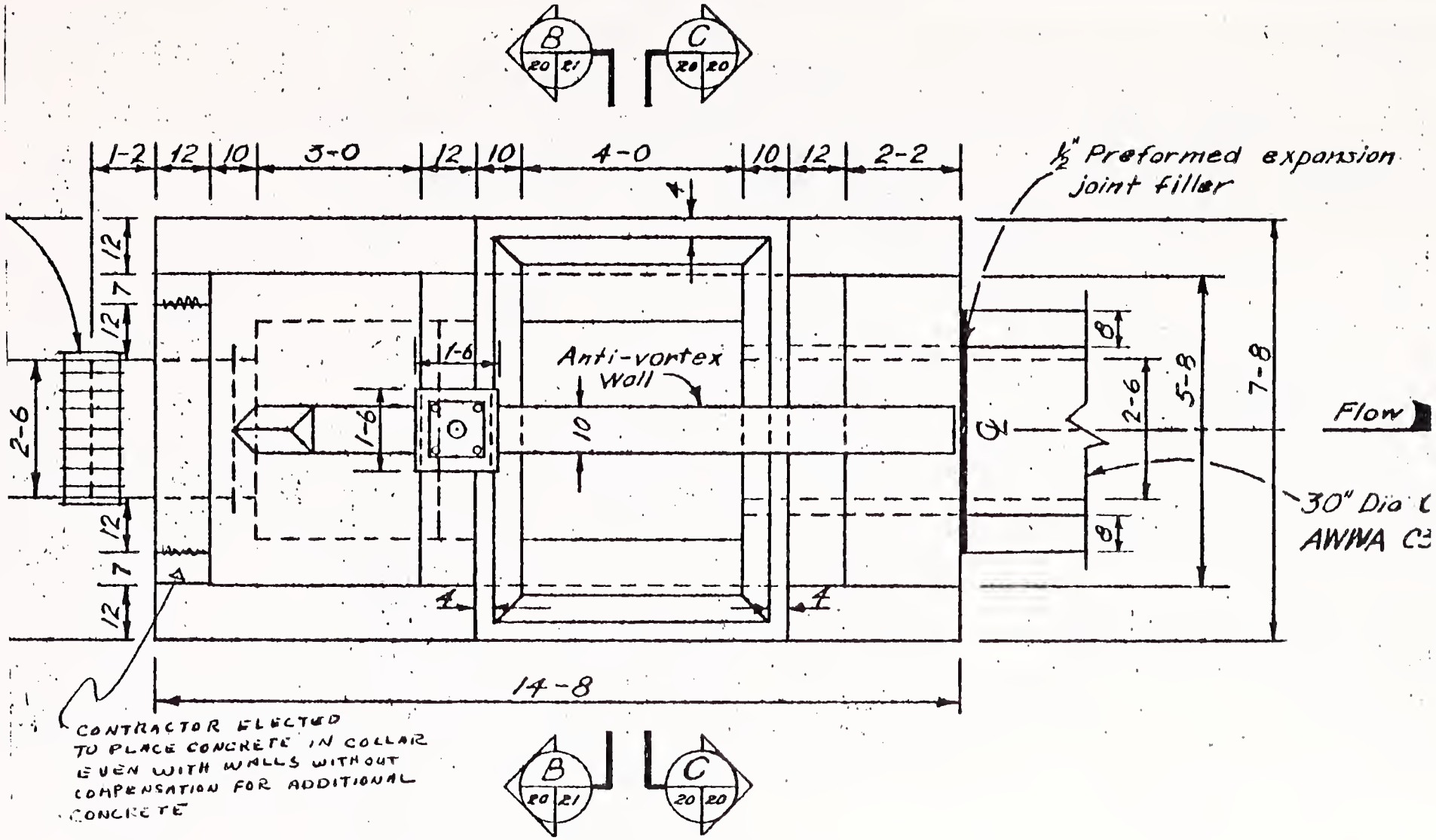
CH2M HILL



SECTION
N.T.S.

PLATE 6
CEDAR CREEK DAM
PRINCIPAL SPILLWAY/
OUTLET WORKS SECTION

CH2M HILL



PLAN

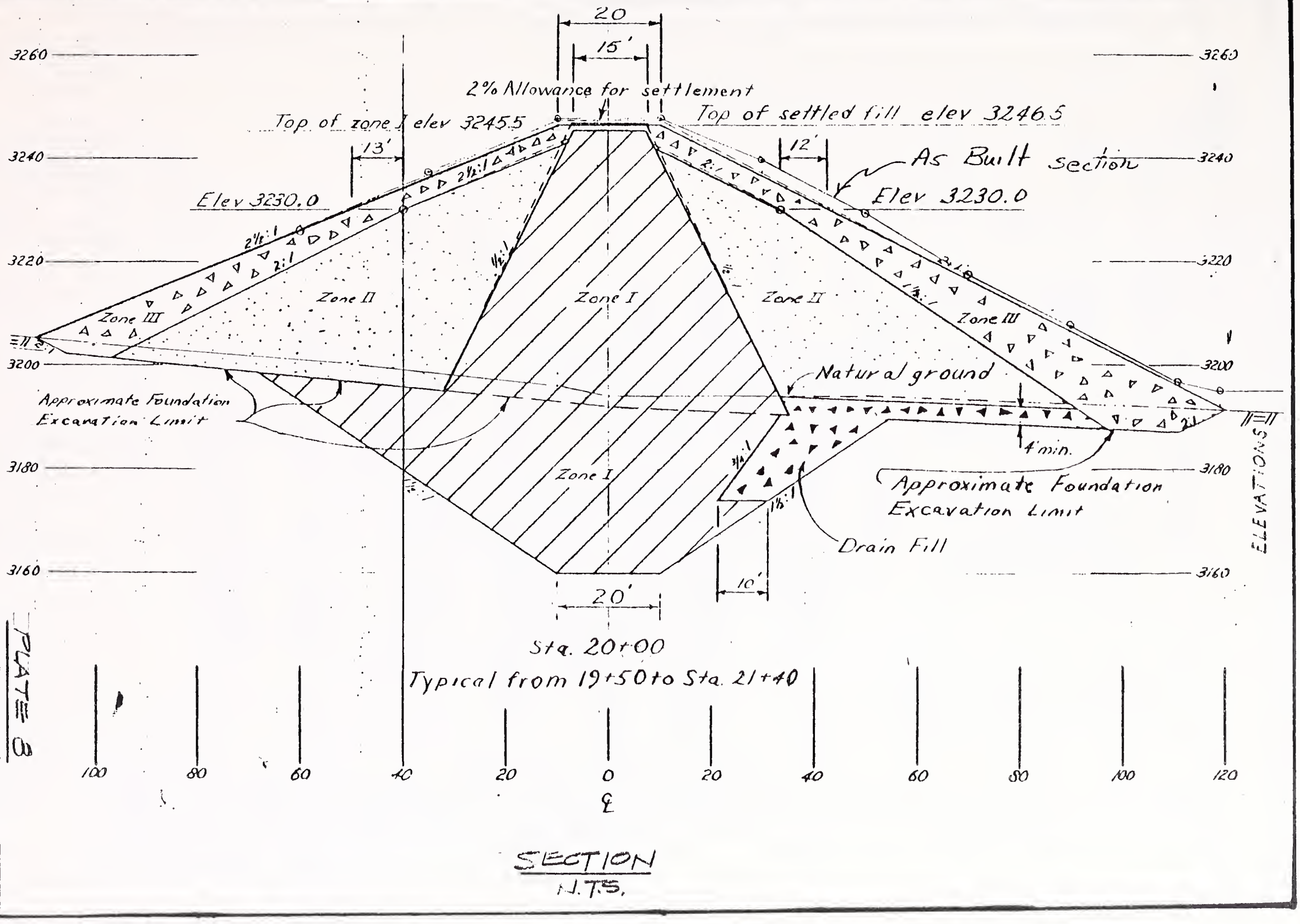
N.T.S.

PLATE 7

CEDAR CREEK DAM

PRINCIPAL SPILLWAY/ OUTLET WORKS PLAN

CH2M HILL



Sta. 20+00
Typical from 19+50 to Sta. 21+40

SECTION
N.T.S.

PLATE 8
CEDAR CREEK DAM
EMBANKMENT SECTION

CH2M HILL

EMBANKMENT PROFILE & BORINGS

Foundation excavation depth approx. 2'

Foundation excavation depth approx. 5'

Foundation excavation depth approx. 2'

ELEVATIONS

3260

3240

Emergency Spillway excavation 3220

Bottom of Core Trench 3200

3180

3160

Sta 14+71.6 Elev. 3243.8

Sta 15+88

Sta 15+08 Elev 3225.5

Sta 16+00

T.H. #21

Sta 17+25

T.H. #22

Sta 18+00 Elev 3225.0

Sta 18+50

T.H. #20

Sta 18+60 Elev 3222.0

Sta 19+70

T.H. #18

Sta 19+80 Elev 3162.0

Sta 19+83

T.H. #24

Sta 20+05

T.H. #14

Sta 20+50

T.H. #13

Sta 20+50 Elev 3155.0

Sta 21+10

T.H. #11

Sta 21+40

T.H. #12

Sta 21+72

T.H. #15

Sta 21+40 Elev 3159.5

Sta 22+00

T.H. #16

Sta 22+00 Elev 3160.5

Sta 22+60

T.H. #17

Sta 23+45

T.H. #10

Sta 22+79 Elev 3187.6

Sta 23+85 #10 P

Sta 23+90 Elev 3209.8

Sta 24+10 #11 P

Sta 25+10 #12 P

Existing natural ground

Sta 26+85 #13 P

Sta 27+60 #14 P

Sta 28+35 Elev 3258.6

Sta 28+56 T.H. #23

Approx. foundation excavation

Approx. bottom of core trench

Sta 27+90 Elev 3213.8

NOTE:
Grades as shown are for initial staking. Final extent of excavation will be determined in the field by the engineer.

NOTE:
SOILS CLASSIFICATION PER UNIFIED SOILS CLASSIFICATION SYSTEM.

Approx. Foundation excavation

Slopes for core trench bottom

S=0.5	S=0.001	S=0.05	S=0.5	S=0.10	S=0.05	S=0.35	S=0.09	S=0.20	S=0.01	S=1.0
15+08		18+00	18+60	19+80	20+50	21+40	22+00	22+79	23+90	27+90

Core trench 1:1 Side slopes 14+71 – 17+05

Core trench 1.5:1 Side slopes 17+05 – 23+20

Core trench 1:1 Side slopes 23+20 – 28+35

PLATE 9

CEDAR CREEK DAM

CH2M HILL